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Kansas Entomological Society

Volume 17 July, 1944 Number 3

# THE THIRTEENTH OR 1943 ANNUAL INSECT POPULATION SUMMARY OF KANSAS[1]

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This insect population summary for Kansas covers the calendar year 1943 and is the thirteenth in a continuous series which began with the year 1931.[4] The information recorded here is based on a summary of 333 questionnaires of the score card type from the sources indicated in Table I together with the observations and comments of the authors, their colleagues and of those returning the score sheets.

TABLE I. Source and Numbers of Questionnaires Summarized for this Report

| | No. in July | No. in October |
|---|---|---|
| Group 1. Entomologists in the state | 13 | 15 |
| Group 2. County Agricultural Agents | 75 | 35 |
| Group 3. Farmers, mostly college graduates | 40 | 35 |
| Group 4. Vocational Agricultural Teachers | 46 | 34 |
| Total reports of each group | 174 | 159 |
| Grand total of all questionnaires summarized for this report | 333 | |

## SUMMARY OF WEATHER CONDITIONS (Fig. I and Table II) IN KANSAS BY MONTHS DURING 1943[5]

**January** had mild weather during most of the month, with an unusually light fall of moisture. A severe cold wave after the middle of the month re-

[1] Contribution No. 533 from the Department of Entomology.

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[3] Extension Entomologist, Extension Division.

Recognition and appreciation for assistance given during the preparation of this summary are due to the same sources and largely to the same individuals who supplied information for recent, previous reports. They consist of the persons classed in Table I.

[4] For the other summaries in this series, see the **Journal of the Kansas Entomological Society** for the summaries for 1931 (vol. 5); 1932 (vol. 6); 1933 (vol. 7); 1936 (vol. 10); 1937 (vol. 11); 1939 (vol. 13); and for 1942 (vol. 16) and the **Transactions of the Kansas Academy of Science** for 1934 (vol. 38); 1935 (vol. 39); 1938 (vol. 42); 1940 (vol. 44) and for 1941 (vol. 45).

[5] Notes and Table II based on Climatological Data: Kansas Section, Weather Bureau, U.S. Dept. of Commerce by S. D. Flora. Vol. 57. 1943.

sulted in some of the lowest January temperatures recorded for the state. Snowfall largely on the 17th and 18th totaled only one to three inches.

**February**, 1943, was the mildest, most pleasant, and driest February on record. The top soil in the western third of the state dried out and there was some wind erosion. Snowfall was deficient, the total being less than an inch. Wheat began to grow.

**March** was unusually deficient in precipitation over the state, and the temperature averaged abnormally cold. Abrupt temperature changes were frequent, and extremes for the month were among the greatest on record in the state. The total precipitation for the first three months was scarcely half of normal. Top soil in the western half of the state dried out badly, and there was considerable wind erosion.

**April** averaged unusually mild over the state, but rainfall in the eastern and south-central counties was exceptionally deficient. Over the eastern third of the state, it was the fourth driest April since 1887. It was also the sixth mildest.

**May** was exceptionally cool and cloudy. There were record-breaking rains and floods in the southeastern counties, but rainfall was deficient in southwestern counties. Below normal temperatures were unfavorable for corn. Fields became weedy due to lack of opportunity to cultivate.

**June** had above normal temperatures, sufficient sunshine, and heavy rains over all of Kansas except the southwestern quarter. Except in the latter area, it was exceptionally favorable for crops. Damaging floods and delays in farm work again occurred.

**July** was a favorable month for crop growth, with temperatures averaging above normal, the usual amount of sunshine and slightly below normal rainfall. Most of the rain fell during the first 19 days, and, in some areas, the last three days. The temperature during the first part of the month was comparatively cool but the average for the month was slightly above normal.

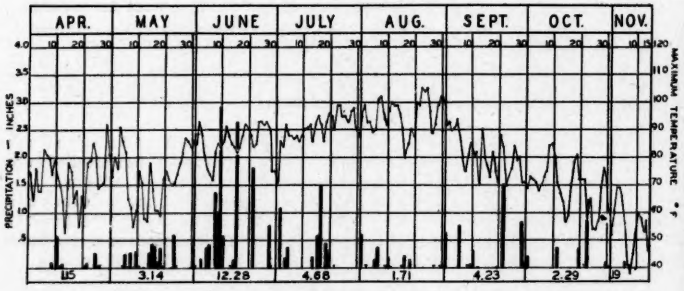



Fig. 1.

TABLE II. Summary of Weather Data for the State of Kansas for the period September 1, 1942 to December 31, 1943

| Month | Temperature in degrees Fahrenheit | | | | | Precipitation in inches | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | State Average | Maximum | Minimum | Average for 57 years | Departure from normal | State Average | Average for 57 years | Departure from normal | Eastern third | Middle third | Western third |
| September 1942 | 66.6° | 100° | 21° | 69.8° | —3.2° | 4.48 | 2.83 | +1.65 | 6.87 | 4.82 | 1.74 |
| October " | 57.8° | 95° | 10° | 57.3° | +0.5° | 2.80 | 1.98 | +0.82 | 2.61 | 2.97 | 2.83 |
| November " | 45.4° | 87° | — 3° | 43.2° | +2.2° | 0.75 | 1.28 | —0.53 | 1.58 | 0.45 | 0.21 |
| December " | 32.4° | 73° | —11° | 33.2° | —0.8° | 1.82 | 0.86 | +0.96 | 2.76 | 1.74 | 0.97 |
| January 1943 | 30.5° | 83° | —28° | 29.8° | +0.7° | 0.18 | 0.68 | —0.50 | 0.23 | 0.17 | 0.15 |
| February " | 40.4° | 82° | 4° | 33.1° | +7.3° | 0.59 | 0.99 | —0.40 | 0.82 | 0.70 | 0.24 |
| March " | 39.5° | 94° | —17° | 43.4° | —3.9° | 0.85 | 1.42 | —0.57 | 1.38 | 0.75 | 0.42 |
| April " | 58.3° | 95° | 18° | 54.9° | +3.4° | 1.96 | 2.56 | —0.60 | 1.71 | 2.11 | 2.07 |
| May " | 60.9° | 98° | 29° | 63.9° | —3.0° | 4.61 | 3.81 | +0.80 | 8.23 | 3.84 | 1.77 |
| June " | 75.4° | 109° | 36° | 73.8° | —1.6° | 5.54 | 4.04 | +1.50 | 9.18 | 4.46 | 2.97 |
| July " | 80.6° | 112° | 44° | 79.2° | +1.4° | 2.85 | 3.11 | —0.26 | 2.79 | 3.62 | 2.13 |
| August " | 82.8° | 113° | 44° | 77.9° | +4.9° | 2.26 | 3.15 | —0.89 | 2.32 | 1.83 | 2.64 |
| September " | 67.5° | 102° | 29° | 69.7° | —2.2° | 2.39 | 2.82 | —0.43 | 4.19 | 2.42 | 0.57 |
| October " | 55.8° | 96° | 11° | 57.3° | —1.5° | 1.67 | 1.98 | —0.31 | 2.45 | 1.96 | 0.59 |
| November " | 42.5° | 82° | 9° | 43.2° | +0.7° | 0.22 | 1.26 | —1.04 | 0.30 | 0.20 | 0.15 |
| December " | 30.8° | 68° | —21° | 33.2° | —2.4° | 1.50 | 0.87 | +0.63 | 2.11 | 1.59 | 0.81 |
| Average extremes or totals for 1943 | 55.4° | 113° | —28° | 55.0° | +0.4° | 24.62 | 26.69 | —2.07 | 35.71 | 23.65 | 14.51 |

**August** was the hottest since 1938, and had the least rainfall since 1937. Only five Augusts in 57 years and only six summers averaged hotter. Rains were frequent but local, and the total rainfall was below normal. The month was decidedly unfavorable to corn, especially late-planted corn in the southern and western parts of the state.

**September** had abundant rains in the south and east-central portions of the state but was exceptionally dry in the western and extreme northern counties. Temperatures averaged below normal but there were no damaging frosts. Corn matured early in the month and wheat-sowing was hampered by dry soil, especially in the western part of the state.

**October** continued to be dry, and conditions were unfavorable for wheat over most of the western and extreme northern counties. Adequate rains occurred elsewhere. The temperatures averaged cooler than usual. The first killing frost occurred on the 15th or 16th.

**November** was rather cool and unusually dry over the whole of Kansas, this being the fifth month of deficient rainfall.

**December** had an exceptionally heavy fall of moisture. Cold weather with snow began the second week and continued throughout the month.

## CROP PRODUCTION SUMMARY FOR 1943[6]

The year 1943 was excellent for crops in Kansas. Wheat production was 144,201,000 bushels, making it one of the largest crops in the state, although it was 62,574,000 bushels less than in 1942, which was second only to the 1931 crop of 252,000,000 bushels. Excellent yields were obtained in the northwestern areas, but they were reduced by late spring freezes and dry weather in southwestern counties and by these factors and hessian fly in the south-central counties.

Oat production was estimated to have been 45,766,000 bushels which is only slightly below the 46,232,000 bushels in 1942.

Barley production was estimated at 15,330,000 bushels which compares with 17,186,000 bushels for 1942 and 26,520,000 bushels in 1941.

Alfalfa seed production in 1943 was estimated at 199,000 bushels or 1.4 bushels an acre compared with 156,000 bushels and 1.3 bushels an acre in 1942.

## DESCRIPTIVE ACCOUNT OF THE MORE IMPORTANT INSECT ACTIVITIES AND CLIMATIC RELATIONSHIPS DURING 1943

The **alfalfa plant bug, Adelphocoris lineolatus** (Goeze) was found more readily in Riley County than ever before. This species while yet uncommon, appears to be increasing.

**Ants.** Winged forms of the genera **Cremastogaster** and **Monomorium** swarmed forth in unusual numbers the latter part of September and early October. They prompted much correspondence and many inquiries as to whether they were termites. They were reported widely in the state.

The **kafir ant** was scored at 2 for Elk County by R. F. Nuttelman. This species is destructive to newly planted sorghum seed in that region of the state. Weather in 1943 was not favorable to this species.

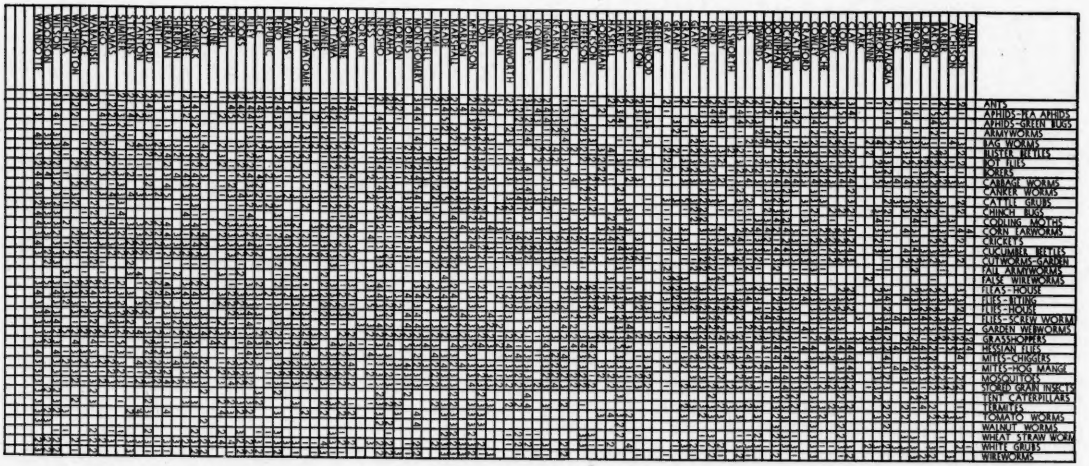
The **mound building ant** was observed just west of Abilene, which is the farthest east this species has been seen. The colony was on flat ground and had no mound.

Several species of **aphids** were in outbreak during 1943, while many others species were less plentiful than usual.

**Pea aphids** occurred in outbreak numbers in counties along the Arkansas River and in other river valley counties. In many regions, the first crop of alfalfa was either lost or seriously reduced by them. First reports were received from Pawnee and Barber Counties the latter part of March. By early April, the aphids had reached outbreak numbers in Pawnee, Barton, Barber, Stafford, Finney, Edwards and Thomas Counties. Later injured spots and fields of alfalfa were observed in Riley, Saline, McPherson, Harvey, Reno, Kingman, Harper, Sedgwick, Sumner, Hamilton, and Wallace Counties. They caused some damage also in Norton, Decatur, and Rawlins Counties in north-

[6] From Kansas 1943 Crop Review, Kans. State Bd. of Agr., Agricultural Statistics Division, Dec. 20, 1943. Mimeographed Release.

TABLE III. Population summary of the more common and important insects in Kansas for 1943, as indicated by questionnaire score sheets from nearly all counties.




Key—

1. Scarce.
2. Plentiful, but damage was neither noticed nor reported.
3. The species was abundant. Some damage was either seen or reported.
4. Local outbreaks. The species was doing severe damage in certain fields.
5. The species was in general outbreak. The insects were doing their greatest damage or were as plentiful as they ever get in a locality.

western Kansas, especially in the Sappa creek valleys, and slight damage in Sheridan and Graham Counties.

In Pawnee County, the loss was estimated by the county agent at a half ton of alfalfa an acre. This county also had large number of aphids in 1942. Pea aphids became numerous in counties north of U.S. highway No. 24, but little or no visible damage was seen or reported. They caused visible injury at the Hays and Colby experiment stations. These insects were plentiful in alfalfa fields in eastern counties, but were too late in the season to cause appreciable hay loss. No loss of alfalfa stands was seen or reported. During the summer, pea aphids were as scarce as usual and they did not increase above normal numbers during the fall. They were present, however, on young alfalfa.

Lady beetles, which reached large numbers by early May, had destroyed most of the aphids in the earlier-infested fields by the latter part of May.

The first growth of alfalfa in 1943 had little bloom. Early cutting was unfavorable to the aphids, and the second growth gave excellent yields.

Many reporters also mentioned this species on garden peas, but apparently little damage was done.

**The green bug** again threatened to develop to outbreak proportions but failed to do so. While this aphid was more plentiful than usual in winter barley, oats and wheat, it was not as common as in 1942, and injury was confined largely to small areas or spots of thin wheat as on poor land. These effects were accentuated by the prevailing dry weather. Early reports came from Harper and Kiowa Counties. By the first of May, the aphids had spread over the entire western half of the state to the Nebraska line, but actual damage was confined largely to the southern and central counties. The green bugs continued to feed upon the developing heads, many of which were shortened, and failed to emerge fully. The greatest damage occurred in Stafford, Edwards, Reno, Seward, Pawnee, Ness, Rush, Ellis, Gove, and Trego Counties. In many fields, green bugs were more plentiful on oats than on wheat. The green bug was finally brought under control the latter part of May by parasites and lady beetles.

Aphids reported to be green bugs became plentiful on fall-sown wheat in the western half of the state during the fall. Three species were present in Riley County on wheat, but R. H. Painter failed to find the green bugs present. The apple grain aphid was the most plentiful, and the English grain aphid appeared to rank second in numbers. Some injury was done by these aphids to late-sown wheat.

**Corn leaf aphids** were observed by R. H. Painter to have been plentiful on corn. This observation was made while on a trip in early August to southwestern counties. These aphids were scored at 3 in Ellis County and 2 in Riley County.

Aphids on elms, spiraea, chrysanthemums, beans, melons and radishes were less plentiful than usual, and lower in numbers than in 1942. Lady

beetles, chrysopids and syrphus flies increased to effective numbers early enough to prevent injuries by those species.

Elm leaf aphids were scarce in 1943 and not a factor in any county in the health of elm trees. They were scored at 4 in Leavenworth County.

Other hosts mentioned in aphid reports were garden crops, especially radishes, melons, and cucumbers. They scored at 5 in Pawnee and Decatur Counties; at 4 in 13 counties; at 3 in 12 counties and at 2 in 7 counties. On apple they scored at 4 in Jefferson and Doniphan Counties; on shade trees, particularly elms, at 4 in Leavenworth County; and on chrysanthemums at 2 from Riley and Doniphan Counties.

**Army worms** were reported widely over the state in early summer, but heavy rains either prevented injuries or hastened recovery in plants. The numbers present were normal, but damage was less than normal, and lower than in 1942.

**Evergreen bag worms** probably were slightly more numerous and destructive in the eastern half of the state in 1943 than in the previous year. They were observed in nurseries fully as frequently as usual, and the number of inquiries about the species was slightly above average.

**The bean leaf beetle** was reported in Riley County by H. R. Bryson to have been numerous and destructive to bean foliage during late summer. In the eastern and southeastern counties, the bean beetle destroyed entire plantings. It was abundant in Cherokee, Labette, Crawford and Johnson Counties. Cryolite dust was an effective control.

**Bedbugs** were somewhat more plentiful than usual, both in homes and checken houses. War workers shifting locations frequently, and the large increase in poultry are believed primarily responsible for the increase in bedbug infestation.

**Bees** did well in Kansas in 1943. The Division of Statistics of Kansas estimated honey production from 44,000 colonies of bees at 1,672,000 pounds of honey compared with 1,400,000 pounds in 1942. The average production per colony was 38 pounds compared with 35 pounds in 1942, and 51 in 1941. The cool, late spring and heavy rains in early June hindered early activity, and the honey flow of sweet clover was cut off sharply near the end of July by the hot, dry weather. There was a small smartweed nectar flow in some areas in August and September. The demand for honey was the greatest for many years. There was little swarming during 1943.

**Leaf cutter bees** damaged foliage of roses and young ash leaves more commonly than usual. They were unusually abundant in Ford and Edwards Counties.

The **bean weevil, Acanthoscelides obtectus** (Say) was observed in Riley County by H. R. Bryson in considerable numbers on flowers, especially tiger and regal lilies, during early July. They ate the pollen but did not damage the flowers. They were readily brought into homes on bouquets.

**Blister beetles** were fairly plentiful during July and August in the western

half of the state and did some injury. Although widely reported from all over the state, actually they were less numerous and destructive than in 1942. Geo. A. Dean observed both the striped and gray species eating alfalfa blossoms, seed pods and foliage in Thomas, Cheyenne, Sherman, Rawlins and Decatur Counties in mid-July. They were less destructive to garden crops than usual.

**Horse bot flies** were widely reported in the state and probably were somewhat more numerous in 1943 than in 1942. County agents reported that veterinarians treated 13,769 animals for 3,025 farmers in 1943.

The **sheep bot fly** continues common and, since the numbers of sheep in the state have increased, it is believed this pest has increased in numbers correspondingly. The flies were observed laying eggs April 30th and infested sheep were seen in May.

**Borers** in trees of various kinds were widely reported but the scores indicated they were less destructive in 1943 and far below the peak of the drought years. They apparently were most destructive in southeastern counties. Elms were mentioned as the chief hosts in 19 counties; apple plum and cherry trees in 7 eastern counties; peach in 11 counties; honey locust, black locust and maple trees were noticeably attacked by borers in 1 to 3 counties for each.

**Box elder bugs** were no more plentiful than in 1943. A relatively small number of adults went into hibernation in the autumn and they caused little annoyance in and around homes.

**Cankerworms** were less numerous than in 1942. Isolated trees outside of cities had severe foliage injury. A few moths emerged early in January but cold weather near the middle of the month stopped the emergence. The fall cankerworm moths reached a peak about February 22 in Riley County. The spring cankerworm moths emerged in February and reached a peak in early March.

Most injury was reported in the eastern fourth of the state, especially southeastern counties but considerable numbers occurred in scattered western counties. Several reported damage to Chinese elms but, in general, elms in the country were chiefly attacked.

**Cabbage worms** were widely reported in the state in 1943 but numbers and damage were no more than occurred in 1942.

**Carrot beetles** were present in normal numbers in 1942. They were observed in gardens in June over most of central Kansas. They were scored at 5 for Stevens County by F. L. Timmons.

**Carrot weevil.** This small weevil was found in many gardens in eastern Kansas. The entire planting was destroyed in the vicinity of Lenexa in Johnson County. It appears to be spreading westward since it was found in Shawnee and Osage Counties last year.

**Cattle grubs** occurred perhaps in normal numbers in 1943, but the eradication of these cattle pests was strongly stressed in extension work with ap-

parently good results. These campaigns were considered a major contribution to the war effort. Early reports of cattle running from the flies were received the latter part of April. Grubs were reported infesting chiefly southern cattle brought in for pasture.

The northern cattle grub was thought to have been present only in Cheyenne County.

There were 116,000 head of cattle treated with derris during the winter 1942-43 in 91 counties in Kansas.

**Calligrapha scalaris** Lec. was reported as causing marked defoliation of elms from April to late summer at Miltonvale and Manhattan. This species was somewhat more plentiful than usual in the state.

**Chinch bugs** were lower in numbers in 1942, and below normal in numbers during 1943. There were good reasons for expecting large numbers of these insects in 1943 with marked damage in the western half of the state but, by May 12, they were actually scarce. Eight adults to a foot of wheat row at Oak Hill, Clay County, was the maximum number seen. The weather continued unfavorable and they did not increase to threatening numbers. No barriers were built and the small number of bugs going into hibernation made fall control measures unnecessary. A little damage was done to some corn along U.S. highway No. 75 and around Wichita. The drouth accentuated the small amount of damage.

A. L. Hallsted reported a few chinch bugs as far west as Hays but, in general, they were scarce beyond a line connecting Ottawa and Sumner Counties.

A considerable population of chinch bugs went into hibernation in the fall from corn and sorghum.

**Clover leaf weevil** larvae were found readily in most clover and alfalfa fields in early April, but the numbers remained small and the species was of no consequence. Crows were reported feeding upon them in the fields.

**Clover seed chalcid** did some damage to alfalfa seed in south-central Kansas counties, according to Geo. A. Dean.

**Codling moths** were exceptionally numerous and destructive during 1943. A normal population of codling moth larvae attacked a half crop of apples with the result that an abnormally high percentage of wormy apples was harvested. Growers thought the crop too poor to protect by sprays up to July, so neglected the early sprays. They then began applying the cover sprays, but with poor results. The low grade, small, wormy crop of apples, however, was sold readily at a higher price than for many years.

It was found while scraping the bark from apple trees in November for codling moth control that an abnormally large population was overwintering under the bark. Erwin Abmeyer reported 115 on one tree and predicted that some trees had 200 overwintering larvae.

**Colorado potato beetles** continued in small and inconsequential numbers, except in Victory gardens, in 1943. They were destructive in a few gardens

up to June 10th but for the season they were below normal in numbers and of no consequence in commercial plantings. The cool, damp, cloudy weather of May apparently proved unfavorable to the eggs and young larvae. Many eggs appeared to be infertile.

**Columbine leaf miner** was more plentiful than for several years.

**The corn earworm** during 1943 was distinctly below normal in numbers and less than last year. Damage to sweet corn, field corn, alfalfa and sorghum heads was less than usual. The species, however, was widely reported, but the scorings were mostly 1 to 3, with no 5's.

**Cotton leafworm moths** were less common than last year and below average in numbers in 1943. They were scored at 4 in Thomas County by J. B. Kuska; 2 in Ellis, Rice, McPherson, Cowley and Lyon Counties, and at 1 in Riley and Gray Counties.

**The cowpea curculio (Chalcodermus aeneus** Bob.) was observed near Hutchinson during May eating the leaves and stems of cabbage. Damage to young cabbage plants by this insect is unusual.

**Crambid moths** appeared in Riley County in large numbers at lights during the first week of October. They were common in grass during the late summer and fall.

**Crickets** invaded some homes during the summer, but this was less common than usual. They occurred in large numbers in the extreme western counties, and they did some damage to parachutes at flying school camps, particularly in Ellis County.

**Cutworms** were found in greater numbers than in 1942 but still were below normal. **Army cutworms** were distributed widely over the state in alfalfa fields in early April, but only slight injury was done. One larva to the square foot was about the largest number seen.

**Garden species of cutworms,** however, were of much greater importance. Many gardens had rather severe cutworm injury up to May 1. P. G. Lamerson reported the garden species as more numerous and destructive in northeast Kansas than last year. Young cabbage and head lettuce plants particularly were damaged by them. They were reported damaging gardens in 65 counties during the spring. Other crops mentioned by reporters were corn in 18 counties, wheat and oats in 4 western counties, and alfalfa in 5 central and western counties.

**Yellow striped armyworms** probably were slightly more plentiful than in 1942. They damaged soybean foliage during July and August.

**Pale western cutworms** were not reported for Kansas in 1943. A. L. Hallsted stated that there was a possibility that this insect may have been responsible for some destruction of wheat plants being cut off below ground, but the cutworms were not discovered. The 3 scoring in Thomas County by E. O. Graper may have been based on this same condition.

**Datanas** on apple, cherry and sumac were unusually plentiful and did serious foliage injury to some trees in late summer.

The **eight spotted forester** larva was more plentiful than usual on the foliage of grape and virginia creeper in early summer than last year. Mr. Wenger reported this species as causing noticeable defoliation at Tribune, Elkhart, Dodge City, and many other places in western Kansas.

**False chinch bugs** were exceptionally plentiful in many central and western counties on wheat, alfalfa and shepherd's purse during early June. The latter plants were killed by them along paths and ends of rows. They were more abundant than for many years.

**False wireworms** were less plentiful than normal in western Kansas in 1943. They were most noticed in the dry areas but they caused no serious damage.

The **fall armyworm** was reported widely but numbers were comparable to those of 1942.

**Fleas** on pets and in homes were common but normal in numbers in 1943.

**Flea beetles** were more numerous and destructive to early gardens in the spring than in 1942. They were scored at 4 for Doniphan County by P. G. Lamerson, and 3 for Riley and Pawnee Counties. They attacked particularly tomatoes, potatoes, egg plant and radishes.

**Flies** of several species developed to abnormally large numbers in 1943 as a response to favorable weather conditions during the spring and early summer.

**Screw worm flies** occurred in a medium outbreak in Kansas during 1943. Weather conditions were favorable for them and they became abnormally plentiful throughout many of the southern states. The flies appeared early in Kansas, and infestations reached a peak of abundance early in July, but continued to be a major stock problem until October. This livestock pest spread over a larger area in the southern and central parts of the United States in 1943 than was ever known before, according to E. W. Laake of the Bureau of Entomology and Plant Quarantine. He classified the outbreak in Kansas as medium or light on a computation of not over 2 percent of livestock attacked.

Screwworms were observed to have been particularly damaging in Cowley, Elk, Chautauqua, Butler, Greenwood, Woodson, Montgomery, Douglas and Doniphan Counties. They were reported as especially abundant in the vicinities of Leavenworth, St. Joseph and Kansas City. In Riley County the outbreak appeared to begin later than usual, and to continue later in the fall. Lester Brock found evidence of them in every county along the southern border of Kansas by the middle of July, and in the western part of Kearny and the eastern parts of Pratt and Kiowa Counties. He stated the percentage of infested cattle was particularly high. They attacked small calves and pigs also. Attacks on sheep and lambs ranked next to cattle in the state, but horses also were mentioned. Farmers treated 42,000 animals for screwworms in 1943.

The **black blowfly** (Phormia regina) attacked sheep in western Kansas during the spring of 1943. For the year, the number appeared to be somewhat less than last year.

**Stable** and **horn flies** probably were more abundant than last year and population peaks occurred following the rains in June and September. They were reported widely over the state and the score numbers indicated more than average annoyance from them.

**Horse flies,** especially **Tabanus sulcifrons**, were exceptionally plentiful near streams in southeastern Kansas counties in June and July. The heavy early summer rains and floods greatly favored these pests of domestic animals. They were scored at 3 in Brown, Cowley, Butler and Doniphan Counties, and at 2 for Johnson County.

**Garden webworms** occurred in mild, scattered outbreaks in 1943. They were reported widely in the state, and important damage was done in many counties in the eastern half of the state. The third cutting of alfalfa particularly was attacked, but garden and corn also were damaged. Soybeans were damaged seriously in many southeastern counties. This is the first report received of damage to the leaves of young soybean plants in Kansas. The moths were plentiful, particularly during August.

These insects developed into a small, irregular outbreak in some alfalfa fields in Riley County the latter part of July. The hot, dry, weather in Riley County apparently was so unfavorable to them and to the eggs that larvae were scarce after mid-August.

While most reports of the webworms were based on damage to alfalfa, they also were reported on sweet potatoes, corn, cane and sorghum. They were particularly destructive to late plantings of these crops.

The **grape leaf folder, Desmia funeralis** (Hbn.) was scored at 5 by P. G. Lamerson in Doniphan County.

**Grasshoppers** were slightly below normal in population during 1943 and damage was confined to a few counties in the western part of the state. The eggs hatched late, and the cold, wet spring caused high mortality. Grasshoppers appeared during July and August to be building up all over the state, especially in the eastern half. However, they did not require control operations in eastern Kansas. By the end of July, the two-lined and differential species were abundant and doing damage to alfalfa in Thomas, Cheyenne, Sherman, Rawlins and Decatur Counties. Weeds in wheat fields supplied the grasshoppers with food, and they moved out of stubble land slowly. The second cutting of alfalfa during the last of July was damaged by them in the Arkansas Rivey Valley. They ate the blossoms and leaves from many acres of alfalfa. Damage over the state was confined largely to feeding at the borders of fields and to some gardens.

During the fall, the two species mentioned and the American grasshoppers were plentiful in patches of soybeans and cowpeas in Riley County. They ate into the pods, as well as doing some foliage injury.

The second generation of the migratory grasshoppers was large in many western counties.

Grasshoppers were most numerous and destructive during 1943 in Cheyenne, Rawlins, Sherman, Thomas, Wallace, Logan, Greeley, Wichita, Scott and Hamilton Counties.

Poison bait was required in several counties for small areas. It is notable that only 937 farmers put out not more than 232 tons of bait during the season.

The fall egg survey showed that the areas adjoining Cheyenne, Sherman, Thomas and Rawlins, Kearny, Finney, Wichita and Scott Counties had the largest deposition of eggs in the soil in the state.

**Green-striped maple worms** defoliated maple trees in Jackson and Jefferson Counties were reported by R. L. Parker. They were scored at 3 for Doniphan County by P. G. Lamerson.

The **hessian fly** was the most destructive insect of 1943 in Kansas. The weather favored this insect and the reduction in the wheat crop from this cause has been estimated at 25,000,000 bushels.

Rains April 7 to 9 brought out the adults in eastern Kansas, and egg deposition was heavy. Many thin stands of wheat were due to plants killed before and during the winter from hessian fly attack. Many fields from Marshall and Washington to Sumner Counties showed severe hessian fly damage in mid-May. As many as 80 to 90 percent of dead plants in some fields contained **flaxseeds** with as many as 50 percent of the tillers infested.

The hessian fly moved westward, the western border of injury being the tier of counties from Jewell to Harper Counties, while the triangular area Miami to Elk and Chautauqua Counties had a light infestation. R. H. Painter reported that there was only a single spring brood and practically no summer brood due to the small amount of volunteer wheat. This was the result of the hot, dry weather during July, August and early September.

The counties enclosed by a line connecting Riley, Reno, Sumner, Lyons and Wabaunsee Counties had the highest hessian fly infestation and suffered the greatest wheat loss. However, the northeastern counties from Nemaha to Wyandotte had only a little lower infestation and loss.

The hessian fly survey at harvest time in Kansas by representatives of the Bureau of Entomology and Plant Quarantine[7] included the following data:

TABLE IV. Harvest time hessian fly survey by representatives of the Bureau of Entomology and Plant Quarantine.

| | Number fields sampled | Stems infested | | |
|---|---|---|---|---|
| | | Average Percent | Maximum Percent | Minimum Percent |
| Western counties | 63 | 1.7 | 30 | 0 |
| North central counties | 34 | 9.2 | 46 | 0 |
| South central counties | 57 | 8.1 | 46 | 0 |
| Northeastern counties | 99 | 12.1 | 74 | 0 |
| Southeastern counties | 57 | 3.5 | 30 | 0 |

[7] Cartwright, W. B. Hessian fly survey at harvest time 1943. Insect Pest Survey special supplement. 3 p. Sept. 15, 1943.

The 12.1 percent stem infestation was the highest report in the United States except 13 percent for New Jersey. The median infestation in the Great Plains states was about 5 percent.

The fall brood of hessian fly adults appeared a little later than usual in 1943 but the safe planting date schedules were satisfactory. Much wheat in the hessian fly areas was planted before the safe date and, in general, it was heavily infested.

**Leafhoppers** attained usual numbers on grape, woodbine, and spiraea bushes during September and October. The potato leafhopper was somewhat more plentiful than usual. This species did marked injury to a small field of alfalfa in Riley County in July. They migrated in from weeds, especially near by"mare's tail." Swarms of this species were noted when potatoes were dug in Kaw Valley fields. There was a heavy flight of leafhoppers and other insects the nights of September 7 and 8.

Leafhoppers were reported on the following plants or crops: Potatoes, scored at 4, in Cowley, Wyandotte and Riley Counties; at 3 from Rice and Neosho Counties, and 1 in three counties; on alfalfa at 4 from Kearny and Riley Counties, and three counties at 2; on wheat or rye at 4 from Kearny, Rush and Sedgwick Counties; on garden crops especially beans, beets, egg plant, cucumbers and melons at 5 in Leavenworth County, at 4 in five counties, at 3 in 11 counties, at 2 in 4 counties and at 1 in four counties; on grapes and woodbine at 4 in Riley and Cowley Counties, at 3 in three counties, at 2 in two counties; on apple at 3 in Morris and Doniphan, and at 2 in Jefferson Counties; on elms at 4 in Douglas, and 2 in Riley Counties and on buffalo grass at 2 in Ellis County.

**Cattle lice** were more abundant and destructive in 1943 than the previous year. Sucking lice alone caused marked unthriftiness and some deaths. Some dipping vats are now in use. The cube-wettable sulphur dusts and dips gave good control results.

Hog lice were plentiful in 1943, but the infestation and injuries were normal.

**Mites,** excepting hog mange mites, were less numerous than in 1942 and during previous years.

**Chiggers** occurred in fair numbers during June but for the year were well below 1942. They were average in numbers or probably somewhat below normal except in the Kaw Valley and southeastern Kansas counties.

**Clover mites** caused annoyance in homes around Garden City in early April, but were sent to the Department of Entomology, Kansas State College for identification from perhaps a dozen addresses during early spring and late fall.

The **tropical rat mite, Liponyssus bacoti** (Hirst) was sent from an infested house in Topeka during the summer and identified by H. E. Ewing, Bureau of Entomology and Plant Quarantine. This and the report by Hungerford (Jour. Kan. Ent. Soc. 16(4)154, 1943) constitute the first authentic reports of

this mite in Kansas. This mite is now spread over most of the United States where it lives in rat nests and sometimes causes great annoyances in homes, stores, offices and factories.

**Hog mange mites** were particularly abundant during the winter and spring of 1942-43. More hogs were treated for this pest in 1943 than for many years. In 74 counties 9,603 farmers treated 174,014 hogs with lime-sulphur dip.

**Red Spider mites** were less numerous than usual in 1943. They occurred in greenhouses and on many evergreens in nurseries during the summer. Little damage was done outdoors. By the end of July, they declined rapidly in numbers, as is usually the case, but the typical salmon color of injured elms was observed during August. These mites scored at 3 in Doniphan, Wyandotte, Neosho, Wilson, Riley, Ellis, Pratt, and Meade Counties; at 2 in 10 widely scattered counties and at 1 in two counties.

The **sheep scab mite** occurred in several flocks in southeastern counties. Most of these flocks were dipped under direction of the State Livestock Sanitary Commissioner.

The **spinose eartick** occurred moderately in some cattle herds during October. For the year, they were less numerous and annoying than last year, or normally.

The **brown dog tick** continued to be the tick most commonly reported by the public. Many dogs were attacked and some houses were known to become infested with them.

The **lone star tick** was found by Missouri entomologists to have been the most numerous species of tick in that state in 1943. It is probable that this was the species of tick reported plentiful on cattle in eastern and southern counties also.

The **redbud leafroller** was scored at 1 for Riley County, indicating below 1942 and normal numbers by R. L. Parker.

**Rose sawflies** were comparable in numbers and damage to 1942. There was some damage done, but favorable growing conditions for roses rendered their attacks of little consequence. They were scored at 4 in Neosho; 3 in Wilson, Cowley, Doniphan, Wyandotte and Ellis Counties; at 2 in 11 eastern and central counties, and at 1 in 10 other counties.

The **potato stalk borer, Trichobaris trinotata** (Say) was scored at 3 by Backus for Wyandotte County, where it attacked tomatoes and potatoes.

**Scale insects** of various species were scarce in 1943. The **red cedar scale** was scored at 3 in Neosho, Harvey and Morris Counties, and at 1 for Kiowa and Riley Counties. Scales on "fruit trees" were scored at 3 for Wyandotte, Doniphan, Labette and Cherokee Counties.

**Sheep ticks** were scored at 3 in Lyon County by J. E. Taylor. County agents reported that 3,500 growers in 84 counties dipped 214,847 sheep and lambs for ticks in 1943. Lamb feeders dip the lambs upon arrival from western states.

**Stored grain insects** were approximately as plentiful in 1943 as during the previous year. They were widely and extensively reported in the questionnaires, generally with the notation that wheat was the grain attacked. R. T. Cotton reported that the lesser grain borer appeared to be more widely distributed in farm stored grain, particularly in the southern half of the state, than in previous years. County agents reported that 14,822 farmers in 92 counties fumigated wheat in farm bins.

**The strawberry rootworm, Paria canella** (Fab.) was scored at 4 in Doniphan County by P. G. Lamerson.

**The strawberry leafroller** was scored at 3 by P. G. Lamerson for Doniphan County which would indicate a normal population and equal to 1942.

**Squash bugs** were abundant and destructive in Riley, Cowley, Sedgwick, Reno and many other counties. Actually this insect and the next prevented a crop of squashes and pumpkins in many gardens.

**The squash vine borer** was observed by H. R. Bryson to have been more destructive than last year.

**The oriental fruit moth** was found in 25 additional counties of Kansas during a special co-operative survey by representatives of the Bureau of Entomology and Plant Quarantine and state inspectors. It was known previously to occur in 27 eastern counties. The map prepared by T. D. Persons, Bureau of Entomology and Plant Quarantine (See unnumbered mimeographed report entitled "The 1943 oriental fruit moth survey." p. 19) indicates the presence of this fruit pest in all counties, except Cloud, east of a line connecting Republic and Harper Counties. Moths were trapped in Ford County also.

**Phenacoccus solani** (Ckll.) a mealy bug was sent in from Wichita on red warba potato sprouts. This is a first report for the state. D. J. Caffey, Bureau of Entomology and Plant Quarantine, reported that it has been recorded on many weeds in California as well as potato and tomato.

**The Southwestern corn borer** increased somewhat in numbers and distribution during 1943. It was found in 29 counties in 1941; 22 more counties were added to the list in 1842,[5] and 10 additional counties in 1943, namely: Dickinson, Logan, Sheridan, Smith, Thomas, Butler, Chautauqua, Montgomery, Elk and Cowley. This corn borer is now as far east as Clay and Marion Counties in the north and Montgomery County in the south. It has reached the Nebraska line in Norton, Smith and Phillips Counties. Corn in Harper, Kingman, Barber, Pratt, Pawnee and Stafford Counties frequently was 80 to 100 percent infested by these borers, and 20 to 90 percent of these stalks had broken over by husking time. There were more 100 percent fields than ever before.

The increase in numbers was particularly noticeable in the first generation borers and a greater amount of "dead heart" injury resulted than has previously been observed in this state. For reasons unknown, girdling of the stalk, prior to corn harvesting was more prevalent, and resulted in a large increase in fallen stalks over the 1942 season.

**Pine sawflies** did noticeable damage to some pine and arbor vitae trees in Riley County during early June.

**Rose sawflies** were slightly more plentiful and destructive to rose foliage in 1943 than in 1942.

**Tomato hornworms** were equal in numbers to 1942. The chief tomato problem in 1943 was a disease, not insects, which caused the fruit to rot.

**Termites** were reported widely in the state but numbers and damage were no more than last year nor than usual. The counties reporting tend to lie in one of the river valleys of the state.

**Walnut worms** were below 1942 and below normal in numbers in the state in 1943.

**Wheat strawworms** were rather widely reported in the state in 1943. In numbers and damage they probably equalled 1942.

**White grubs** did somewhat more damage to potatoes and gardens in 1943 than in the previous year.

**Wheat white grub** adults were not plentiful in 1943 as this was the year for the larvae to appear in the two-year life cycle. Many wheat fields in southern and western Kansas were damaged by the larvae. A. L. Hallsted said he had never seen them so numerous. Fields were seen where there were as many as three grubs to the foot or drill row. Reports of white grub injury to wheat, necessitating re-drilling in part or all, probably were due to this species. Early sown wheat in McPherson, Stafford, Pawnee, Edwards, Rush, Barton, Rice and Harvey Counties were attacked by wheat white grubs, but only thinning of stands resulted. The grubs appeared in far western counties for the first time. Many fields were damaged in Wallace, Logan, Sherman, Rawlins and Thomas Counties.

**Wireworms** were not particularly plentiful in 1943 and probably were below 1942 in numbers. They were reported feeding on potatoes in 7 eastern counties; on corn in 13 eastern counties, and on tomatoes and other garden crops in 5 counties.

## SUMMARY AND CONCLUSIONS

### Temperature and Moisture

The year 1943 was near normal in temperature or slightly cooler and above normal in rainfall. It was a year of good crops and a pleasant year generally. December was slightly above normal in temperature and below normal in moisture. February was 7° above normal in temperature and below normal in moisture. The early spring was abnormally cool. The rainfall in May and June was well above normal and disastrous floods occurred along many streams. Precipitation from July to December was below normal. The soil in central and western counties was too dry for good wheat growth. Temperature conditions from September to mid December were exceptionally pleasant and the first killing frost came after crops were mature.

**Insect Occurrence**

Outbreak numbers: pea aphids, green bugs, screwworm flies; garden webworm, and hessian fly.

**More numerous than in 1942:** alfalfa plant bug, apple grain aphid, bagworms, bean leaf beetle, carrot weevil, bedbugs, leaf cutter bees, horse bots, sheep bot, cattle grubs, cattle lice, codling moth, garden species of cutworms, yellow striped armyworm, Datanas, eight spotted forester moth, false chinch bugs, garden flea beetles, house flies, horse flies, stable and horn flies, certain leafhoppers, swine mange mites, squash bugs, squash borers, oriental fruit moth, Southwestern corn borer, wheat and garden species of white grubs.

**As plenitful as in 1942:** house and lawn ants, corn leaf aphids, armyworms box elder bugs, carrot beetles, cabbage worms, Colorado potato beetles, army cutworms, fall armyworms, fleas in homes, rose sawflies, stored grain insects, tomato hornworms, termites, wheat strawworms and wireworms.

**Less plentiful than in 1942:** elm and garden species of aphids, borers in trees, blister beetles, cankerworms, chinch bugs, clover seed chalcids, corn earworms, cotton leafworm moths, black crickets, false wireworms, black blowflies, grasshoppers, red cedar scale, chiggers, red spider mites, spinose ear ticks, redbud leafroller, walnut worms and wheat white grubs.

**Scarce:** clover leaf weevil and clover mite.

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## THE ROLE OF SORPTION IN THE FUMIGATION OF STORED GRAIN AND MILLED CEREAL PRODUCTS

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It has long been recognized that the fumigation of stored grain and milled cereal products is complicated to a greater or less degree by the factor of sorption. Concentrations of most gases that kill insects in an otherwise empty container and with a given exposure period have little or no effect on the insects in a similar period if the container is filled with materials such as grain or flour. Very much higher concentrations are required to compensate for the fumigant sorbed by the material. Methyl bromide is an exception in that only a slight increase in dosage is required for the fumigation of a container when it is filled with milled cereal products.

Experience has shown that advantage can be taken of the capacity of cereal products for sorbing fumigants. The Law of Haber, that the toxic action of a fumigant is proportional to the degree of the concentration and the length of the exposure, holds in the fumigation of these products, and the vapors sorbed by them can be utilized to extend the period of fumigation until a satisfactory kill is obtained.

In experimental work on vacuum fumigation, 500 pounds of flour in 24-pound cloth bags were fumigated for 30 minutes with a dosage of liquid hydrocyanic acid (8 oz.), which had been established as the correct dosage for a 3-hour exposure for that quantity of flour. Adults of the confused flour beetle, **Tribolium confusum** Duv., buried in the middle of the bags of flour were all alive when removed immediately after the fumigation. Others left in the flour for 48 hours, however, showed a mortality of 83.4 percent due to the action of the sorbed gas.

Diffusion of hydrocyanic acid through bags of flour is not obtained as quickly under atmospheric conditions as it is in a vacuum, but the gas absorbed in an overnight fumigation is retained and exerts a lethal effect for a considerable period of time after the flour is removed from the fumigating chamber. This is indicated by the data of Table 1, in which are recorded the results of the experimental fumigation of three lots of flour with liquid hydrocyanic acid in a concrete vault of 1,145 cubic feet capacity. Several lots of flour-beetle adults that had been buried in bags of flour before the fumigation were removed and examined when the flour was taken out of the vault, whereas others were removed 48 hours later.

TABLE 1—Effect of gas absorbed by flour on flour beetles left in flour bags 48 hours after removal from fumigation with hydrocyanic acid in a 1,145-cubic-foot concrete vault.

| Amount of Flour in vault | Temperature of Flour | Exposure Period | Dosage of Liquid HCN per— | | | Kill of Flour Beetles | |
|---|---|---|---|---|---|---|---|
| | | | Vault | 1,000 cu. ft. | 1,000 lbs. of flour | Immediately after Fumigation | 48 Hours Later |
| Pounds | °F | Hours | Pounds | Pounds | Pounds | Percent | Percent |
| 8,000 | 88 | 18 2/3 | 1.5 | 1.3 | 0.18 | 41.6 | 66.6 |
| 6,000 | 88 | 15 | 2 | 1.75 | 0.33 | 36.6 | 95.0 |
| 8,000 | 82 | 20 | 2.5 | 2.2 | 0.31 | 58.3 | 100.0 |

In all cases the kill obtained 48 hours after the fumigation was very much greater than that immediately after the flour was removed from the vault. Balzer[1] in 1942 observed: "Rice readily absorbs hydrocyanic acid and very slowly liberates it on exposure to the air—a feature that is of considerable advantage, since the insecticidal effect persists for some time after the rice has been removed from the vault." In unpublished notes made available to the writers, he recorded that rice after fumigation for 15 minutes in a vacuum chamber with liquid hydrocyanic acid, at a dosage of 1¼ ounces per 1,000 pounds of rice, retained enough gas so that rice weevil adults removed from

[1] Balzer, A. I. Insect Pests of stored Rice and Their Control. U. S. Dept. Agr. Farmers' Bul. 1906:19. 1942

the rice 72 hours later showed a mortality of 99.4 percent, although weevils removed from the rice immediately after the 15-minute exposure were unaffected by the fumigant.

In recent work on the fumigation of wheat in tightly calked steel bins it has been found that fumigants are retained by the wheat for unusually long periods, with the result that the insecticidal action is extended much longer than would ordinarily be supposed. This long-time retention of fumigants was suspected when injury to the germination of wheat was sustained from dosages of fumigants known to be safe for ordinary exposure periods. In order to determine the length of the period that fumigants were retained in lethal concentrations in bins of wheat, lots of insects were inserted in the grain at weekly intervals after a bin had been fumigated, and exposed for 5 or 6 days to the vapors held by the grain. This procedure was continued as long as any insecticidal action from the retained fumigant was observed. The insects were exposed to the action of the fumigant by means of probes or "check sticks" composed of dowels 2 or 3 feet long, fastened together with perforated sheet-metal sleeves in such a manner that a small cell was formed at each union. A metal-cloth cylinder or a gelatin capsule with silk-cloth ends filled with wheat and insects was placed in each cell. The check sticks could be made of any length desired and were thrust vertically to the bottom of the bins so that insects would be exposed at from 2- to 3-foot intervals from the top to the bottom of the bins.

By this means it was determined that fumigants were retained in killing concentrations by the wheat for varying periods, depending on the gas used, the quantity applied, and the temperature of the grain. In general, the cooler the grain and the greater the volume of fumigant applied the longer it was retained. The 3-1 mixture of ethylene dichloride and carbon tetrachloride is usually applied in larger quantities than most grain fumigants and, as shown by the data of Table 2, may be retained in killing concentrations for as long as 4 months.

TABLE 2.—Retention of 3-1 mixture of ethylene dichloride and carbon tetrachloride in wheat in steel bins

| Capacity of Bin | Date of Fumigation | Bins Fumigated | Dosage per M bu. | Average Mortality of Grain Insects after — | | |
|---|---|---|---|---|---|---|
| | | | | 7 Weeks | 12 Weeks | 16 Weeks |
| Bushels | | Number | Gallons | Percent | Percent | Percent |
| 1,000 | June 11 | 3 | 4-6 | 84 | ..... | ..... |
| 2,740 | June 10 | 5 | 4-6 | 84 | 63 | ..... |
| 2,740 | Jan. 6 | 1 | 4 | ..... | ..... | 58 |
| Check insects in untreated bins | ..... | ..... | ..... | 32 | 11 | 18 |

The long-time retention of this fumigant serves the very useful purpose of protecting bins of wheat from migrating insects during the critical period late in the summer and early in the fall, when grain temperatures are high enough to favor insect breeding. At Hutchinson, Kans., where experimental grain fumigation was carried on, the mean temperature of wheat stored in steel bins is ordinarily favorable for active insect development only during the summer months. At this period of the year, grain-infesting insects fly into the bins and may cause serious loss unless the proper methods of suppressing them are applied. By studying the rate of development of insect infestation in a number of calked steel bins receiving different treatments, it was learned that by fumigating the bins late in August with a 3-1 mixture of ethylene dichloride and carbon tetrachloride, developing infestations were stopped and sufficient fumigant was retained to protect the grain from migrating insects for the remainder of the warm weather. The natural cooling of the grain in the fall and winter protected it from damage until the following summer. Data regarding the development of insect infestation in wheat in calked steel bins, as affected by time of fumigation, are given in Table 3. The same dosage of fumigant was used in all these bins.

TABLE 3.—Development of insect infestation in calked steel bins of wheat, as affected by the time of fumigation with a mixture of ethylene dichloride and carbon tetrachloride, Hutchinson, Kans., 1943.

| | | | Number of Insects per 1,000-gram Sample[1] on— | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Size of Bins | Date of Fumigation | Bins Observed | May 10 | June 10 | July 1 | July 15 | Aug. 1 | Aug. 16-22 | Sept. 3-16 | Oct. 1 | Oct. 25-30 |
| Bushels | | Number | | | | | | | | | |
| 1,000 | None | 2 | 2 | 2 | 4 | 17 | 46 | 47 | 61 | 29 | 21 |
| 2,740 | August | 3 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| 1,000 | Aug.-Oct. | 2 | 3 | 6 | 18 | 41 | 49 | 0 | 2 | 1 | 0 |
| 2,740 | Sept. | 3 | 1 | 1 | 3 | 5 | 14 | 28 | 39 | 0 | 0 |
| 1,000 | Oct. | 2 | 0 | 1 | 2 | 8 | 13 | 32 | 34 | 93 | 1 |
| 2,740 | Oct. | 3 | 0 | 1 | 1 | 2 | 9 | 11 | 13 | .... | 1 |

Owing to this phenomenon of long-time retention of fumigants by wheat in steel bins, it has been found that fumigants formerly considered too low in toxicity to be of practical value can be used very successfully. Carbon tetrachloride, long used in admixture with flammable chemicals to reduce the fire hazard and with more toxic compounds to increase the volume and aid distribution, has been successfully used alone in calked steel bins at a dosage of 3 gallons per 1,000 bushels. At the end of a week's exposure a complete kill of all stages of grain-infesting insects has been obtained consistently.

[1] Average of 5 samples.

The tenacity with which wheat in steel bins retains the vapors of grain fumigants was demonstrated when a calked bin of wheat treated with carbon disulfide at the rate of 2 gallons per 1,000 bushels was transferred to another bin 3 days later. Check sticks containing capsules of grain heavily infested with insects were thrust into the grain the day after it has been transferred, so that insects were exposed at 2-foot intervals from the surface to the bot-

TABLE 4—Effect of fumigation with a mixture of ethylene dichloride and carbon tetrachloride, containing 10 percent of methyl bromide, on the viability of wheat stored in calked steel bins, Jamestown, N. Dak.

| Bin | Percentage of Germination | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capacity and No. | Aug. 1941 | Feb. 1942 | Aug. 1942 | Nov. 1942 | Feb. 1943 | May 1943 | Aug. 1943 | Total Change |
| **Fumigated Bins** | | | | | | | | |
| **2,740 bu.** | | | | | | | | |
| R-1 | 94 | 92 | 65 | 36 | 24 | 20 | 16 | —78 |
| R-2 | 89 | 70 | 56 | 26 | 30 | 14 | 17 | —72 |
| S-1 | 92 | 72 | 60 | 44 | 44 | 32 | 30 | —62 |
| P-5 | 87 | 82 | 72 | 50 | 48 | 22 | 28 | —59 |
| Q-5 | 91 | 89 | 55 | 28 | 28 | 20 | 17 | —74 |
| R-5 | 93 | 84 | 61 | 53 | 51 | 38 | 17 | —76 |
| S-4 | 94 | 85 | 74 | 58 | 56 | 56 | 32 | —62 |
| Average | 91.4 | 82.0 | 63.3 | 42.1 | 40.1 | 28.9 | 22.4 | —69 |
| **1,000 bu.** | | | | | | | | |
| G-5 | 90 | 90 | 84 | 70 | 73 | 60 | 42 | —48 |
| H-5 | 94 | 96 | 90 | 39 | 41 | 31 | 36 | —58 |
| Average | 92.0 | 93.0 | 87.0 | 54.5 | 57.0 | 45.5 | 39.0 | —53 |
| **Unfumigated Bins** | | | | | | | | |
| **2,740 bu.** | | | | | | | | |
| J-4 | 90 | 90 | 84 | 84 | 81 | 88 | 87 | — 3 |
| K-4 | 95 | 90 | 93 | 89 | 90 | 90 | 86 | — 9 |
| K-5 | 94 | 92 | 86 | 90 | 93 | 92 | 87 | — 7 |
| P-4 | 93 | 90 | 83 | .... | 88 | 80 | 83 | —10 |
| Q-4 | 90 | 92 | .... | .... | 92 | 88 | 84 | — 6 |
| R-4 | 93 | 92 | .... | .... | 90 | 88 | 80 | —13 |
| S-3 | 93 | 87 | 79 | .... | 88 | 86 | 80 | —13 |
| Averages | 92.6 | 90.4 | 85.0 | 87.7 | 88.9 | 87.4 | 83.8 | — 8.6 |
| **1,000 bu.** | | | | | | | | |
| G-4 | 90 | 82 | .... | 80 | 85 | 86 | 83 | — 7 |
| H-4 | 91 | 92 | .... | 85 | 90 | 89 | 93 | + 2 |
| Average | 90.5 | 87.0 | .... | 82.5 | 87.5 | 87.5 | 88.0 | — 2.5 |

tom of the central column of the grain. When the insects were removed 3 days later an average mortality of 99 percent throughout the bin had been obtained.

Unfortunately the long-time retention of certain fumigants causes injury to the germination of grain. At Jamestown, N. Dak., a series of nine calked steel bins of wheat has received three annual fumigations with a 3-1 mixture of ethylene dichloride and carbon tetrachloride containing 10 percent of methyl bromide. The first fumigation was given in November 1941, the second in August 1942, and the third in September 1943. An equal number of bins of the same type received no treatment during the entire period. The bins were filled in July 1941 and sand-bench germination tests were run for both series of bins at intervals of about 3 months thereafter. As shown by the data in Table 4, there was a decided decrease in the viability of the grain in the fumigated bins, from an average of 91.4 to an average of 22.4 percent in the 2,740-bushel bins, and from an average of 92.0 to an average of 39.0 percent in the 1,000-bushel bins. The data also show that the decrease in viability was not so rapid in the 1,000-bushel bins as in the larger ones, even though all the bins received the same dosage of 2 gallons of the fumigant per 1,000 bushels. This difference is doubtless due to the fact that the fumigant was retained longer in the larger bins. In the series of bins that received no fumigation, the germination decreased from an average of 92.6 percent to an average of 84.0 percent in the 2,740-bushel bins, and from an average of 90.5 percent to 88.0 percent in the 1,000-bushel bins.

Germination injury has also been observed with mixtures containing carbon disulfide, chloropicrin and 1, 1-dichloro-1-nitro-ethane and with carbon tetrachloride alone. The 3-1 mixture of ethylene dichloride and carbon tetrachloride is the only fumigant tested that appears to have little if any effect on germination, regardless of the length of the period it is retained or the number of times it is applied.

Corn in uncalked steel bins does not appear to retain fumigants for long periods. This may be due to the greater leakage factor in such bins and in part to the lower sorptive capacity of corn and to the greater air space between the kernels. Germination tests of shelled corn after fumigation have not shown any loss in viability due to the retention of fumigants.

Data available at the present time indicate that in spite of a considerable loss in viability of wheat due to fumigation, little consistent damage results to the baking qualities of flour made from such wheat.

# A NEW PSEUDATRICHIA FROM BRAZIL
(Omphralidae-Scenopinidae)

D. ELMO HARDY
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This is the only species of Pseudatrichia known to the writer from the New World, south of Mexico. With the exception of one Australian species, **P. mariaensis** Hardy, the genus is known only from Nearctic America and Mexico. **Pseudatrichia chilensis** Krober[1] was found to belong to a new genus and Krober has named it **Heteromphrale.**[2]

**Pseudatrichia punctulata** n. sp.

This species appears more closely related to **longurio** (Loew) but is readily distinguished by the square tipped, robust third antennal segment, the elongated head, narrowly separated eyes and the short $R_4$ in the wing.

**Male.**—Chiefly metallic blue black species. **Head**: Distinctly longer than high from side view, eyes oval (fig. a). Front polished, silvery just above the antennae; face greatly sunken in, thinly silvery pubescent. Lower portion of occiput polished black, upper part opaque gray. Eyes narrowly separated on the front, front at middle narrower than the median ocellus. Antennae dull black, first two segments with a few weak bristles; third segment about twice as long as first two, sparsely pale haired and square at tip (fig. b). **Thorax**: Minutely punctulated on the dorsum, with very fine appressed pubescence. Humeri and pleurae smooth and without pubescence. Halteres chiefly black, apices of knobs very faintly whitish. Thorax scarcely over one-fourth as long as abdomen and less than half the wing length. **Legs**: Coxae and trochanters yellowish. Femora chiefly black, bases of first two pairs slightly yellow. Tibiae and tarsi chiefly yellow, bases of tibiae and the apical two tarsal subsegments blackish. **Wings**: Faintly fumose and iridescent, the costal and subcostal cells are brownish. Vein $R_4$ at or but slightly beyond the middle of cell $R_5$, and $R_4$ is about equal in length to the section of $R_{4+5}$ from r-m crossvein to furcation, or from r-m to its base. Crossvein r-m situated at about its own length from apex of discal cell (fig. c). **Abdomen**: Eight times as long as its greatest width, completely covered with minute punctules. Hypopygium longer than seventh abdominal segment, narrowed basally and rather bulbose in the median portion; terminal structures not well developed (fig. d). Entire hypopygium rather thickly covered with short yellow hairs.

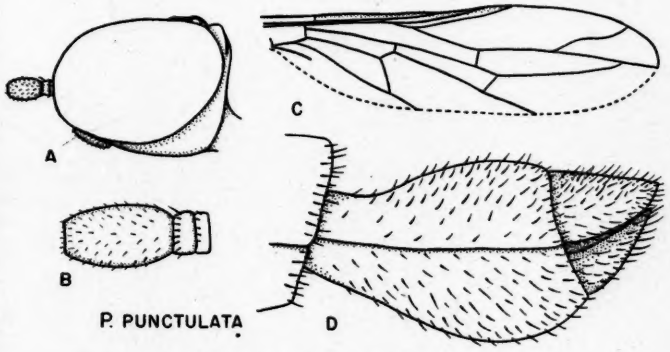
Length: body, 6.6-7.3 mm.; wings, 3.7-3.9 mm.

[1] 1932, Dipt. Patag. and S. Chile, Pt. 5, pp. 258-260.
[2] 1937, Stett. Ent. Ztg. 98, p. 213.

**Female.**—Front slightly narrower than the width of the ocellar triangle, with two rows of weak frontal hairs. Third antennal segment more distinctly pointed at apex above and below. Upper portion of occiput more strongly swollen and genital portion of abdomen with more dense, longer yellow hairs; otherwise like the male.

Length: body, 7.5-8.3 mm.; wings, 4-4.3 mm.

Holotype male: Brasilien Nova Teutonia, 27° 11′ S. 52° 23′ L., 20/11/1940 (Fritz Plaumann). Allotype female and two paratypes, a male and a female, same data. All types in Snow Entomological Collections.




EXPLANATION OF DRAWINGS

**Pseudatrichia punctulata** n. sp. a. head of male, lateral view; b. antenna; c. wing; d. male hypopygium, lateral view.

## THE BIONOMICS OF SCHISTOCERCA OBSCURA (FABR)

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Oklahoma Game and Fish Commission.

During the recent grasshopper outbreak in Oklahoma, one of the large so-called "bird grasshoppers," **Schistocerca obscura** (Fabr.), became unusually abundant and of minor economic importance. The occurrence of this species in fairly large numbers presented an unusual opportunity for obtaining much needed information on this interesting genus in North America.

**S. obscura** is a large grasshopper averaging from 34-40 mm. in length in the males and from 50-61 mm. in length in the females. In fresh specimens the general body color is dark olive green. Usually there is a narrow dorsal stripe of pale yellow color, which is conspicuous against the purplish-brown

color of the tegminae. According to Blatchley (1920) the structural characters are much the same as in **S. alutacea**, except that the pronotum has the median carina more sharply defined and slightly higher. The cerci of the males are somewhat narrower, with the outer apical third concave and the tips truncate.

The genus **Schistocerca** includes some of the most destructive grasshoppers in the world today. **S. gregaria** in Africa and **S. paranensis** in South America are agricultural pests of the first rank. These species are distinctly migratory and **gregaria** has been extensively studied with reference to its alternating "migratory" and "solitary" phases.

This paper deals with the life history and certain color changes brought about by varying the conditions under which the nymphs were reared. These color changes are believed to show a tendency for this species to assume a partial migratory phase. The work was done at Stillwater, Oklahoma, from June 1938 to July 1939. Except for the cases mentioned, the rearing was done in the Entomology Greenhouse of Oklahoma Agricultural Experiment Station.

## GEOGRAPHIC DISTRIBUTION

**Schistocerca obscura** has a wide range of distribution. Scudder (1899) gives records from southeastern Colorado, New Mexico, and Central America. According to Blatchley (1920) its range extends south and west from Baltimore, Maryland, to Texas and New Mexico, and as far north as Iowa and Nebraska.

The earliest record in literature concerning the presence of this species in Oklahoma is that of Caudell (1902). Morse (1907) collected the species again five years later near Caddo, Okla. In 1927 Hubbell and Ortenburger give this record in their list of Orthoptera for the state. The latest reference to **Schistocerca** and **obscura** is that of Hebard (1938) in which he lists the species from Tulsa, Okmulgee, and Weatherford, Okla. The available records of the museum of the Department of Entomology, Oklahoma Agricultural and Mechanical College, show **obscura** to occur throughout the state. The largest population encountered during the course of the work was in Kiowa County, where this species caused considerable damage to wheat.

## DESCRIPTION

**Egg and Egg Pod**—The egg pod when deposited has an elongate-cylindrical neck, slightly narrower than the rest of the pod. The entire length averages 47 mm, and the eggs are arranged in much less order than is the case with most of the other local species.

The egg when freshly deposited is elongate-cylindrical, slightly bent in the middle and tapering towards the ends. The posterior cap is broadly rounded at the end and the ring is not plainly evident. The surface of the chorion is sculptured with a definite pattern of slightly raised lines. The color is brick-red, but this becomes darker with age. The eggs average 6.37 mm. in length at the time of oviposition, but as the embryo matures the egg enlarges, and at the time of hatching reaches an average size of 6.78 mm.

**The Intermediate Nymph.**—Length 8.0 mm. being slightly larger than the first instar. The body is enclosed in a transparent, membranous sac which has extended pouches for the appendages. The head is bent downward, the antennae are close to the frontal region and the mouth parts hang continuous with their attachment to the cranium, not bent inward as in later stages. The genital segments are little developed, the cerci appear as conical extensions of the segment, the males have the ninth abdominal segment slightly notched on the posterior margin of its sternite. The two wing segments are distinguished by their lower posterior margins being rounded and slightly expanded.

**First Instar.**—Length 6.5 mm., color green. In the female the genital plate rudiments of the first valvulae appear as flattened lobes of the termination of the eighth sternite, which is considerably wider than ninth sternite; the second valvulae are not developed externally, and the third valvulae show conical processes which arise from the posterior part of the ninth sternite. The male genitalia are indicated by the expanded sub-genital plate with notched posterior margin and somewhat flattened cerci.

**Second Instar.**—Length of males 10.2 mm., of females 11 mm. Color green. The first valvulae are separated from the eighth abdominal sternite and extend to the anterior margin of the ninth sternite. The second valvulae are small and located between the bases of the third valvulae which show some sclerotization on the outer margins of their lobes. The sub-genital plate in the male is more expanded and the cerci are more flattened than in the first instar.

**Third Instar.**—Length of males 15 mm., of females 18.5 mm. Color green. Small wing pads appear with their ventral margins almost horizontal and with tegminal rudiments clearly differentiated from the rest of the prothorax so that only the tips of the tegminae are exposed. The rudiments of the ovipositior are further developed, the first valvulae nearly overlapping the second and tapering abruptly from the middle to the tips. The male genitalia are clearly distinguished by the swollen sub-genital plate, deeply notched at the end, and by the flattened cerci.

**Fourth Instar.**—Length of males 21 mm., of female 23 mm. Color green. The wing pads are upturned, approximately between the tips and covering the rudiments of the tegmina. The genital segments are similar to those of the adult but with less sclerotization, and the sub-genital plate of the male is not so upturned or expanded as in the adult.

**Fifth Instar.**—Length of males, 26 mm., of females 38.5 mm. The general color remains green, but the adult coloration of purplish-brown shows through the integument just before the final molt. Wing pads same as in preceding stage.

## BIOLOGY

**Food Habits.**—With the exception of some specific experiments in host-plant preference, the principal food used in the rearing cages was American

elm. Other common plants were tested, but it soon became evident that **Schistocerca obscura** had decided preferences concerning its food. It was then planned to study these plants on basis of preference. Since the rearing was carried out in the greenhouse where humidity and temperature conditions were not normal it seemed likely that food consumption here would not indicate a normal outside preference, so food plant studies were done in cages outside of the greenhouse.

Four different species of plants were placed in three cages, each cage containing five individuals of each sex of **Schistocerca obscura** adults. The plants were replaced each morning with a series of four different species. At the end of each day's test, each plant was rated on a basis of from one to four for preference. When the entire group of 22 species of plants had been tested, those having the same rating were then tested against each other. For example cotton, elm, ash, persimmon and wheat were given the same rating on different days. They were then offered to the grasshoppers at the same time. The results of this experiment are shown in Table 1.

TABLE 1.—Food Plant Preferences of **Schistocerca obscura** Stillwater, Oklahoma, 1938

| Group 1 * (Preferred) | Group 2 (Readily Eaten) | Group 3 (Less Readily Eaten) | Group 4 (Eaten only when others not available) | Group 5 (Not Eaten) |
|---|---|---|---|---|
| American elm (Ulmus americanus) | Green mature corn (Zea mays) | Alfalfa (Medicago sativa) | Ash (Fraxinus spp.) | Black Walnut (Juglans nigra) |
| Cotton (Gossypium herbaceum) | Persimmon (Diospyros virginiana) | Apple Pyrus malus) | Black Locust (Robinia pseudoacacia) | Young corn (Zea mays) |
| | Wheat (Triticum vulgare) | Blackjack oak (Quercus marilandica) | Peach (Prunus persica) | Cottonwood (Populus deltoides) |
| | | Hackberry (Celtis occidentalis) | Red bud (Cercis canadensis) | Mulberry (Morus spp.) |
| | | Sumac (Rhus spp.) | | Pecan (Hicoria pecan) |
| | | Virginia creeper (Parthenocissus quinquefolia) | | Soybean (Saja max) |
| | | | | Grasses (various genera) |

* Plants most preferred in Group 1; those less preferred in order, left to right.

In the field, a more or less seasonal cycle of food plant preference was noticed. This cycle, which represents the probable feeding habits as a typical habitat for the species in this area, is as follows: The nymphs hatching in the spring feed on the leaves of the low scrubby elm growth until reaching maturity. On reaching the adult stage the insects move to other foods, although elm still occupies an important place in their food habits. In localities where corn and cotton fields are bordered with elm, the adults first move to the corn to feed; however, this occurred after the corn had reached a height of some five feet or better. No feeding on young corn was noticed either in the field or in the laboratory. Later, when the corn is fully mature and commencing to dry out, the grasshoppers move to the cotton, where they may cause considerable damage by feeding on the leaves. Always, however, there is considerable movement between corn, cotton and elm trees. In the late fall young wheat may be attacked if the field is so situated as to be near a locality suitable for oviposition, since this species congregates at these places in the fall for depositing the eggs.

**Copulation:** The males of this species seem to be susceptible to sexual stimulation at a much earlier time after the last molt than are the females. Several males were seen attempting to copulate within a short time after the last molt and this was noticed to be particularly true when freshly molted males and females were placed together in the same cage.

With caged females, reared under laboratory conditions, the length of time from the date of the last molt to the first copulation was 18 days (Table 2). This may be sooner than with females living under natural conditions, as Pospelov (1934) concluded that caging females shortened the time required for reaching sexual maturity.

**Oviposition:** The typical habitat for oviposition usually consisted of a creek bordered with elm trees or low scrubby elm growth and a sandy soil. The eggs, as a rule, were found to be deposited in the soil around the bases of the young elm growth, particularly on the creek banks.

TABLE 2.—The Pre-Copulation Perior of **Schistocerca obscura**—Females

| Cage No. | Date of Last Molt | Date of Copulation | No. of days from last molt to first copulation |
|---|---|---|---|
| 3 | July 24 | Aug. 8 | 16 |
| 6 | July 23 | Aug. 12 | 21 |
| 9 | July 23 | Aug. 4 | 13 |
| 7 | July 23 | Aug. 4 | 13 |
| 10 | July 19 | Aug. 16 | 29 |
| 15 | July 21 | Aug. 5 | 16 |
| Average number of days | | | 18 |

In general this species seems to bear out the observations on egg development made by Pospelov (1934) on the migratory locust in Russia. This writer found that females did not develop eggs in the ovaries until copulation had taken place. He states that fertilization is in itself a factor which permits the maturation of the eggs in the ovaries.

In following out Slifer's plan (1936) for securing eggs from unfertilized females, the author isolated five female adult **Schistocerca obscura** which had freshly molted. These were kept caged without males for a period of approximately two months, at which time dissection showed that three of the individuals had not developed eggs in their ovaries. One of these females was then placed with a male; copulation immediately took place and eventually one egg pod was deposited. On the death of this female about ten days after the egg pod was deposited, dissection showed another batch of well developed eggs.

Actual oviposition was observed in two cases in the laboratory with the aid of specially prepared oviposition cages. These consisted of glass jars filled with sand, the surface of which was covered with cardboard with the exception of a small margin around the edge. A female ovipositing could easily be seen through the side of the jar. The time required for oviposition averaged approximately 30 minutes. The bottom of the egg mass was inserted to a depth of about ten centimeters in the soil and the top was capped with a mass of froth which extended to just below the surface of the ground. The eggs were glued together with the mucilaginous secretion of the female and particles of soil adhered to the outer surface, forming a somewhat stable covering for the eggs. The average number of eggs per female in this study

TABLE 3.—Number of eggs found in ovaries of **Schistocerca obscura** females collected from the field.

| Date of Collection | Number of Eggs |
|---|---|
| Sept. 30 | 110 |
| Aug. 20 | 120 |
| Aug. 20 | 116 |
| Aug. 28 | 87 |
| Oct. 16 | 167 |
| July 26 | 118 |
| Aug. 8 | 70 |
| July 28 | 109 |
| July 28 | 114 |
| Aug. 21 | 116 |
| Aug. 21 | 119 |
| Oct. 16 | 101 |
| July 25 | 93 |
| Average number of eggs | 108.4 |

was found to be 75.4 for the first pod, 42 for the second and 31 for the third pod. These averages are based on 35, 10 and 4 records respectively. In a few cases a fourth egg pod was deposited but the number of eggs in these was not determined.

At various times, females collected from the field were dissected to determine the number of mature eggs in the ovaries. Over this period, extending from July 25 until October 16, 1938, 13 females were examined. It is not known whether these females had previously oviposited or not, but it may be assumed in some cases they had in view of the late dates on which they were taken. Table 3 gives the results of this study.

The pre-oviposition period, or the period from the last molt until the time of oviposition, has been determined in this work to be 44.1 days. This average was taken from ovipositions of 12 females reared in the greenhouse. The average approximates that given by Ballard (1932) for the solitary phase of the desert locust in Egypt. The interoviposition periods between the first and second egg pods ranged from 5 to 11 days with an average of 8 days for 4 records. For the second and third egg pods this period was 9 and 21 days for two females.

**Hatching:** The eggs of this species are laid in late summer and fall and hatch the following spring. With some species of insects, overwintering at low temperatures seems to be a necessary factor in development. In the case of **Schistocerca obscura** there is no evidence to prove that this is so. Rather, there is much to indicate that the development of the embryo may be continuous if a sufficiently high temperature is maintained. Egg pods deposited in September were broken in halves and stored at both room and outside soil

TABLE 4.—Incubation Period of **Schistocerca obscura** from Eggs Stored at Room Temperature. Stillwater, Oklahoma, 1938—1939.

| Cage No. | Pod Number | Date of Oviposition | Date of First Hatch | Minimum Incubation Period (days) |
|---|---|---|---|---|
| S3 | First | Sept. 1, 1938 | Jan. 8, 1939 | 98 |
| S24 | " | Sept. 5, 1938 | Jan. 7, 1939 | 92 |
| S2 | " | Sept. 6, 1938 | Jan. 11, 1939 | 105 |
| S8 | " | Sept. 7, 1938 | Jan. 8, 1939 | 91 |
| S25 | " | Sept. 5, 1938 | Dec. 10, 1938 | 64 |
| S1 | " | Sept. 1, 1938 | Dec. 5, 1938 | 64 |
| S15 | " | Sept. 1, 1938 | Dec. 15, 1938 | 74 |
| S7 | " | Sept. 1, 1938 | No Hatch | |
| S6-1 | " | Sept. 3, 1938 | Dec. 7, 1938 | 63 |
| S6-2 | Second | Sept. 7, 1938 | Jan. 3, 1939 | 88 |
| | | | Main Minimum Incubation Period (days) | 83.1 |

temperatures. The eggs stored at room temperatures (Normal room temperatures maintained approximately at 68° F.) started hatching in December and continued to do so up until the last of February (Table 4). On examination, the eggs stored at outside soil temperatures showed very little development April 6, 1939. These eggs, however, started hatching in May and the last pod hatched early in June (Table 5). It is interesting to note that there was much difference in the total percentage of eggs hatched, between the eggs in the two localities (Table 6 and 7).

In order that the hatching process might be easily observed, a number of eggs were placed in moist sand in a tin container and allowed to stand in the sunlight until activity was seen to have begun. Time records were kept in a few cases but it soon became evident that the environment of the egg influenced the duration of the hatching period. In general, those individuals hatching after 4 o'clock in the afternoon remained in the intermediate stage until around 8 o'clock the next morning. Also removing the tin containers from direct sunlight to shade in mid-day was sufficient to decrease the activity considerably.

The average hatching time was 16 minutes, as observed from the cages in mid-day. For these same individuals the average length of the intermediate stage was 5 minutes. This stage is considered as being from the time the young are freed from the egg until the intermediate skin is shed.

To free itself from the egg, the embryo makes use of the pulsatile organ (cervicle ampula) which is plainly evident at this time, being located just back of the head. By alternate contraction and expansion of this organ the shell is

TABLE 5.—Incubation Period for Eggs of **Schistocerca obscura** at Soil Temperature. Stillwater, Oklahoma, 1938—39.

| Cage No. | Pod Number | Date of Oviposition | Date of First Hatch | Minimum Incubation Period (days) |
|---|---|---|---|---|
| S3 | First | Sept. 1, 1938 | May 30 | 271 |
| S24 | " | Sept. 5, 1938 | May 31 | 267 |
| S2 | " | Sept. 6, 1938 | May 25 | 260 |
| S25 | " | Sept. 5, 1938 | May 25 | 261 |
| S10 | " | Sept. 7, 1938 | May 30 | 264 |
| S1 | " | Sept. 1, 1938 | May 4 | 245 |
| S15 | " | Sept. 1, 1938 | May 3 | 244 |
| S6-2 | Second | Sept. 7, 1938 | June 2 | 274 |
| S7 | First | Sept. 1, 1938 | May 27 | 268 |
| S6-1 | " | Sept. 3, 1938 | May 21 | 259 |

Mean Minimum Incubation Period (days) 261.3

burst and the nymph makes its way from the egg. According to Uvarov (1928) the movement to the surface of the ground is accomplished in much the same way. The movement of the cervicle ampula forces the soil particles to one side; and, on contraction, the young grasshopper moves upward through the space left by the displaced soil particles.

Uvarov (1928) states that light is a necessary factor in the intermediate

TABLE 6.—Average hatch for **Schistocerca obscura** Eggs Stored at Room Temperatures. Stillwater, Oklahoma, 1938—39.

| No. Cage | of Eggs Number | Number of Hatched 5ggs | Percent of Eggs Hatched |
|---|---|---|---|
| S3 | 25 | 3 | 12.00 |
| S24 | 17 | 3 | 17.64 |
| S2 | 18 | 4 | 22.22 |
| S8 | 22 | 2 | 9.09 |
| S25 | 21 | 4 | 19.04 |
| S10 | 29 | 3 | 10.34 |
| S1 | 14 | 1 | 7.10 |
| S15 | 31 | 1 | 3.20 |
| S6-1 | 23 | 2 | 8.69 |
| S7 | 21 | 1 | 4.76 |
| S6-2 | 22 | 1 | 4.54 |
| | | Average | 10.87 |

TABLE 7.—Average Hatch for **Schistocerca obscura** Eggs Stored at Soil Temperatures. Stillwater, Oklahoma, 1938—39.

| Cage No. | Number of Eggs | Number of Hatched 5ggs | Percent of Eggs Hatched |
|---|---|---|---|
| S3 | 15 | 6 | 40 |
| S24 | 45 | 6 | 11.11 |
| S2-1 | 52 | 10 | 19.23 |
| S25 | 137 | 44 | 32.11 |
| S10 | 28 | 22 | 78.57 |
| S6-2 | 54 | 41 | 75.92 |
| S7 | 45 | 38 | 84.44 |
| S6-1 | 129 | 76 | 58.91 |
| | | Average | 50.30 |

molt and that the young grasshoppers will not hatch, move to the surface of the ground, or molt in the absence of light. With this species it was found that the young would hatch, move to the surface, and complete the intermediate stage in the absence of light. In some cases considerable development toward the second instar was accomplished before death occurred. In this experiment, the eggs at the time of oviposition were confined in tin boxes with tight fitting lids. The boxes were not opened until the insects had reached the various stages of development as stated above. Twenty-four young were hatched in this manner, of which 22 completed the intermediate molt.

**Rate of Development: Schistocerca obscura** developed fastest at the highest temperature maintained during this study, namely 89.8° F. (Table 8). At this mean temperature it completed its development, on an average, in 46.1 days. At the slightly lower mean temperature of 85° F. development was completed, on an average, in 51.2 days; and it is interesting to note that development of the insects reared at outside conditions was completed in approximately the same time. No nymphs were reared to maturity at the lower temperatures maintained because the experiment was terminated before these records could be obtained. However, development was retarded in the earlier instars at these temperatures. As expected, there was considerable range in the duration of the development at the different temperatures.

TABLE 8.—Number of Days Development of **S. obscura** Nymphs at Different Temperatures. Stillwater, Oklahoma, 1938

| Instar | Mean Temperature During Period of Development OF. | | | | |
|---|---|---|---|---|---|
| 85.0 | 75.8 | 70 | 85.9 | | Outside Check |
| 1 | 7.4 | 7.5 | 10.2 | 11.1 | 8.6 |
| | 10* | 17 | 4 | 23 | 57 |
| 2 | 5.2 | 6.0 | 8.2 | 10.2 | 7.0 |
| | 10 | 17 | 4 | 15 | 48 |
| 3 | 11.2 | 13.4 | ..... | 14.1 | 10.1 |
| | 8 | 7 | | 17 | 45 |
| 4 | 11.9 | 12.7 | ..... | 17.7 | 13.1 |
| | 5 | 4 | | 9 | 47 |
| 5 | 10.4 | 11.6 | ..... | ..... | 12.7 |
| | 4 | 4 | | | 40 |
| Total | 46.1 | 51.2 | ..... | ..... | 51.5 |

*Lower right-hand corner represents number of records.

## REACTION OF NYMPHS OF SCHISTOCERCA OBSCURA TO POPULATION DENSITIES AND CONTROLLED TEMPERATURES.

While collecting nymphs in the field it was noticed that occasionally individuals of extremely dark coloration appeared. These, on molting to the adult stage, produced the typical **Schistocerca obscura,** which could not be distinguished from those adults reared from the green nymphs. In the field no gradations were noticed by which the dark colored forms could be connected with the typical green forms.

In rearing the typical green specimens it was noticed that those individuals reared in the greenhouse gradually developed a darker coloration in pattern. However, they never reached such an extreme of coloration as the few collected from the field. A complete gradation from the extreme dark phase to the typical solid green phase was never found in the work of 1938. As mentioned before, the green nymphs showed considerable variation from each other but the dark purplish phase seemed constant.

Since the greenhouse temperatures were below those recorded for the outside, the tendency of the nymphs to change colors suggested that temperatures was one of the influencing factors. It also seemed possible that the apparently two different types might be regarded as the results of two different genetic strains. It was decided, therefore to rear nymphs at different temperatures the following summer to see if an explanation was available as to the relationship of the nymphal variation.

**Method of Experimentation:** The temperature experiments with **Schistocerca obscura** were carried out with the aid of specially constructed temperature cabinets, equipped with thermostatic controls. Constant temperatures ranging from 89.9 to 70 degrees F. were maintained throughout the course of the experiment. The four temperatures maintained during the first part of the experiment were 89.9, 85-70, and 70 degrees F. Later the cages with fluctuating temperatures (85-70 F.) were discontinued. Check experiments were carried on at outside conditions. All dates of moulting and development of the nymphs were recorded. Coloration was checked at one day after moulting in each case in order that equal evaluation might be given to each individual. The food consisted of elm leaves, which were supplied each morning. The rearing cages were made of circular wire gauze placed over flower pots, and all checks on coloration and measurements were taken under a microscope at 23 magnifications.

**Color Development:** In Table (9) is shown the principal color development of nymphs of **Schistocerca obscura** reared at different temperatures and population densities. Only the characteristic colors or general color patterns are included; to do otherwise would go beyond the bounds of tabulation. This table therefore shows the principal differences as they occurred. The variations and intensities developed here in **Schistocerca obscura** are as extreme as those described by other workers for species known to exhibit the migratory phase. With the adults, however, this work terminated before indicative

TABLE 9.—Comparison of Color Development in **S. obscura** Nymphs Reared at Different Temperatures and Poplation Intensities.

| Temperatures (° F). | Population Condition | GENERAL COLORATION | | | | |
|---|---|---|---|---|---|---|
| | | 1st Stage Nymphs | 2nd Stage Nymphs | 3rd Stage Nymphs | 4th Stage Nymphs | 5th Stage Nymphs |
| 70° | Crowded [2] | Deep [3] green | Deep green black speckling *11 | Black 12 | Black-yellowish-red markings 10 | Black-reddish brown 8 |
| | Isolated [1] | Deep green | Deep green *5 | Deep green 3 | Deep green black spotted 10 | Deep green heavy black spotted 12 |
| 85° | Crowded | Deep green | Green 16 | Green with black speckling 11 | Green with black speckling 10 | Brown-pinkish brown 10 |
| | Isolated | Deep green | Light green 8 | Light green 2 | Whitish to light green 4 | Whitish green 4 |
| | Crowded | Deep green | Light green 12 | Light green black speckling 14 | Olive green black speckling 8 | Light tan 8 |
| 89.9° | Isolated | Deep green | Very light green 8 | Very pale light green 3 | Very pale light green 3 | Very pale bluish green to dirty white 4 |
| | Crowded | Deep green | Deep green black speckling 10 | Black 50 | Black with yellow blotches 10 | Black-reddish brown 10 |
| Outside | Isolated | Deep green | Deep green 7 | Deep green black specks 2 | Deep green black speckling 2 | Deep green heavy black spotted 2 |

* Number of specimens examined; This number represents average of lot reared at each particular condition; 1 Isolated—one specimen per cage; 2 Crowded—10-40 individuals per cage; 3 Typical green 1st stage numphs.

data could be obtained, and whether they would show migratory phase characteristics is not known.

That temperature had some effect on the intensity of coloration of **Schistocerca obscura** nymphs is seen by comparing the cases described in Table 9, where all the nymphs reared under the same population conditions but under different temperatures, vary in their coloration. All of the crowded nymphs show a darker coloration than the isolated nymphs but within themselves this group exhibits a gradation from lighter to darker coloration as the corresponding temperatures run from high to low.

With this species, however, the most important factor contributing toward a darker pigmentation seems to be population density. Crowded nymphs show far greater development of dark color than the isolated nymphs reared at the same temperature. A crowded condition seems to exist when more than two nymphs are reared together in a cylindrical cage 8 inches in length by 3½ inches in diameter. In some cages as many as 40 nymphs were so reared. These showed an extreme development of black color.

Movement could be observed at all times in the cages containing the crowded nymphs. As the number of nymphs was increased per cage the movement became more noticeable. That movement is a contributing factor in color arrangement has been shown by Husain (1936). This writer found that nymphs could be kept moving by arrangement of a special revolving tube. The nymphs so reared developed black coloration regardless of the temperature and population conditions.

## SUMMARY

In the region of Stillwater, Oklahoma, cotton, elm, green mature corn, leaves, persimmon and young wheat are preferred foods for the **Schistocerca obscura.**

The pre-copulation period of the female was found to be 18 days. The pre-oviposition period after copulation was 44.1 days. The inter-oviposition period between the first and second egg pods was found to average 8 days and between the second and third pods it ranged from 9 t o 21 days. The average number of eggs per pod was found to be 75.4 for the first pod, 42 for the second and 31 for the third.

The incubation period averaged 261.3 days for eggs stored at outside temperatures and 83.1 days for eggs stored at room temperatures of approximately 68°F. The average hatch for the eggs stored at the two conditions was found to be 10.87 percent for those eggs stored at room temperature and 50.30 percent for those stored at outside temperatures.

Total duration of the nymphal period at outside temperatures was found to be 51.5 days as compared with 46.1 days for those reared at 89.9° F., and 51.2 days for those reared at 85°F. Nymphs reared at the lower temperature of 70°F. did not complete the fifth nymphal period before termination of the work but development of the earlier stages at lower temperatures indicated that much more time would be required at these temepratures.

* Number of specimens examined; This number represents average of lot reared at each particular condition; 1 Isolated—one specimen per cage; 2 Crowded—10-40 individuals per cage; 3 Typical green 1st stage nymphs.

Temperature and population density, especially the latter, were found to affect color development to a marked degree; lower temperatures and crowding producing the darker forms.

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# SOME NEW SPECIES OF CUERNA (Homoptera-Cicadellidae)

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and
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In order that some of the specific names may be available in disease transmission studies, the following descriptions are published in advance of a revision of the genus. A key to the species and illustrations will be published later.

**Cuerna occidentalis**, n. sp.

Resembles **C. limbata** (Say) but is bronze in color instead of black, with veins often light. Length 6-8 mm.

**Structure:** Distance between eyes is to median length of crown as 4.5 is to 3.5. In dorsal view front margins of head almost straight, slightly less than a right angle, apex sharp for this genus.

**Color:** Head, pronotum and scutellum black with rather fine light markings. Light arcs of front usually covering outer third of anterior half of crown, leaving a dark wedge-shaped area between them. Elytra bronze in color, quite rugulose, veins light or dark, apical cells whitish subhyaline.

**Genitalia:** Aedeagus with two pairs of basal processes. In caudal view inner pair about half as long as outer, widest at base, gently curved in to almost touch just before middle, then curved out to end about even with small blunt teeth on aedeagal shaft; outer pair widest at base, arising dorsad of base of inner pair, diverging at about a right angle an basal two thirds, then curving parallel with aedeagal shaft, tapered on outer third, curving caudad to end in sharp points slightly beyond apex of aedeagal shaft. In lateral view inner processes widest on basal third, straight, paralleling aedeagal shaft, gradually tapered on outer two thirds to short points; outer processes slightly wider than inner, about parallel-sided on

basal two thirds, sides sharply converging and often curving slightly caudad on outer third to end just beyond tip of aedeagal shaft.

Holotype male, allotype female and 7 female paratypes, Mint Canyon, Calif., July 6, 1933, J. D. Beamer. Other paratypes: 9 males and 16 females, Alpine, Calif., July 9, 1929, R. H. Beamer; 7 males and 8 females, San Jacinto Mts., Calif., July 21, 1929, R. H. Beamer; 5 males and 4 females, same data, July 31, 1936; 12 males and 10 females, San Diego, Calif., July 4, 1929, L. D. Anderson; 3 males and 3 females, same data, R. H. Beamer; 4 males and 4 females, Santa Maria, Calif., July 19, 1932, R. H. Beamer; 2 males and 2 females, Beaumont, Calif., July 26, 1933, R. H. Beamer; 5 males and 1 female, Laguna Mts., Calif., July 6, 1929, R. H. Beamer; 1 male and 2 females, Laguna Beach, Calif., July 25, 1933, R. H. Beamer; 10 males and 14 females, Anza, Calif., July 29, 1938, R. I. Sailer; 5 males, same data, R. H. Beamer; 2 males and 2 females, Atascadero, Calif., July 19, 1933, R. H. Beamer; 3 females, Redlands, Calif., Aug. 8, 1940, Christenson; 1 male and 2 females, Cala. 2353, C. F. Baker; 1 female, Los Angeles Co., Calif., Coquillett; 1 male, Glenville, Calif., Aug. 30, 1918, A. Wetmore.

Types and paratypes in the Snow Entomological Collections; paratypes in the United States National Museum.

**Cuerna obtusa** n. sp.

Resembling **C. lateralis** Fabr. but distinctly smaller, crown without a yellow marginal line between eyes; angle of front margin of head usually greater than a right angle and outer processes of aedeagus in lateral view extending about half their length caudad to shaft of aedeagus. Length 6.5 to 7.5 mm.

**Structure:** Distance between eyes is to median length of crown as 5 is to 3. Front margin of head usually obtuse, broadly rounded.

**Color:** Head, pronotum and scutellum black with ivory to yellow spots, front margin of crown without yellow stripe connecting eyes. Elytra with costal area red, tips of elytra including apices of anteapicals usually evenly subhyaline, remainder lighter red with dark longitudinal stripes in the cells.

**Genitalia:** Aedeagus with two pairs of processes. In caudal view inner pair heavy, reaching at least a fifth their length beyond tip of aedeagal shaft; outer processes more slender, curving caudad on outer third; aedeagal shaft with swelling on outer third about as wide as tip with two pairs of stubby teeth on outer margin. Aedeagus in lateral view with inner processes sharp, broadest near outer third and extending beyond shaft; outer processes as wide as inner, rather evenly curved caudad from base to tip, widest about middle, extending almost half their length caudad of shaft.

*Continued next issue*

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